UNIVERSITAT POLITÈCNICA DE CATALUNYA
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BEKASI-EAST JAKARTA AIRPORT
AIR SIDE

Report

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1 Airport location and characterization

1.1 Location

The main influence on the airport location is the presence of other airports in the area. Since Jakarta has already one airport, the 18th worldwide, the location has to be selected carefully. Other factors that influenced the airports final location were the ease to provide the airport with good connections to the city and a wide area available in order to increase the airports infrastructure if needed in the future. After considering all those factors, the location decided can be defined by the following coordinates:

- Latitude: 6°08'21"

- Longitude: 107°06'40"

- Altitude: 30meters approximately.

Since the area chosen is extremely marshy, the excavations to deeper levels are going to be avoided as much as possible due to its difficulties and cost. However, that type of terrain gives us some advantage due to its flatness.

1.2 Meteorology

1.2.1 Temperature

The reference temperature of airports is important to be calculated as soon as possible since it has an effect on the performance of the airplanes during the phases of landing and takeoff.

In order to calculate this temperature, the definition given by the OACI will be used. OACI states that: “The aerodrome reference temperature shall be the monthly mean of the daily maximum temperatures for the hottest month of the year (the hottest month being that which has the highest monthly mean temperature). This temperature shall be averaged over a period of years”.

Taking into account the hypothesis that the temperatures obtained on Soekarno-Hatta Airport can also be used in order to calculate our reference temperature due to the fact that both airports are only separated by a distance of 60km, a comparison study has been made.

The final reference temperature obtained is $T_{ref} = 32,38°C$.

The temperature values and study is further detailed in the attachments.

1.2.2 Wind

In order to calculate the influence of the winds the first thing done is the graph of the winds intensity and their direction. This graph is commonly called wind rose graph. The graph obtained making use of Microsoft Excel software is:

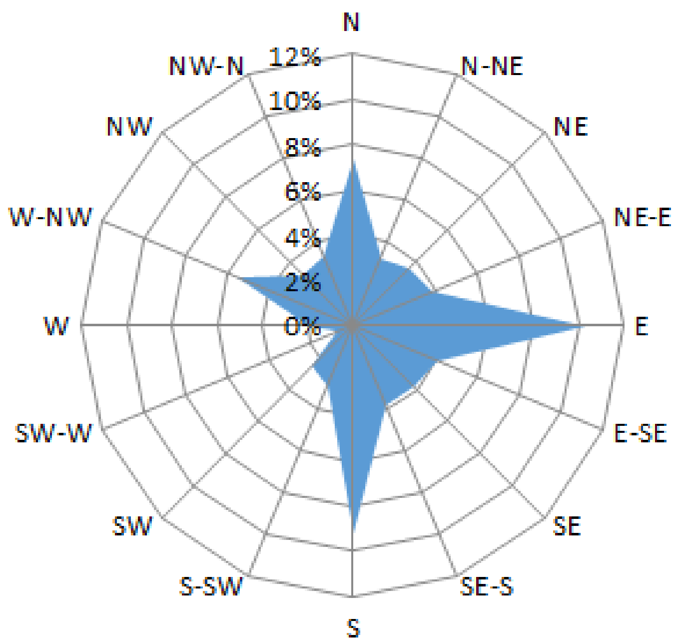

Figure 1.2.1: Wind Rose Graph

Once this step is done, the next thing to do is to calculate the coefficient of use by a diagram of frequencies. Following the recommendations given by the ICAO on the attachment 14, the maximum value that the transversal component can achieve is 37km/h or 20knots for a runway of >1500m.

The diagram of frequencies basically creates a rectangular area that depends on the runway axis, the width of the runway and the maximum transversal component.

After calculating the coefficient of use by all the directions, the graph obtained is the following:

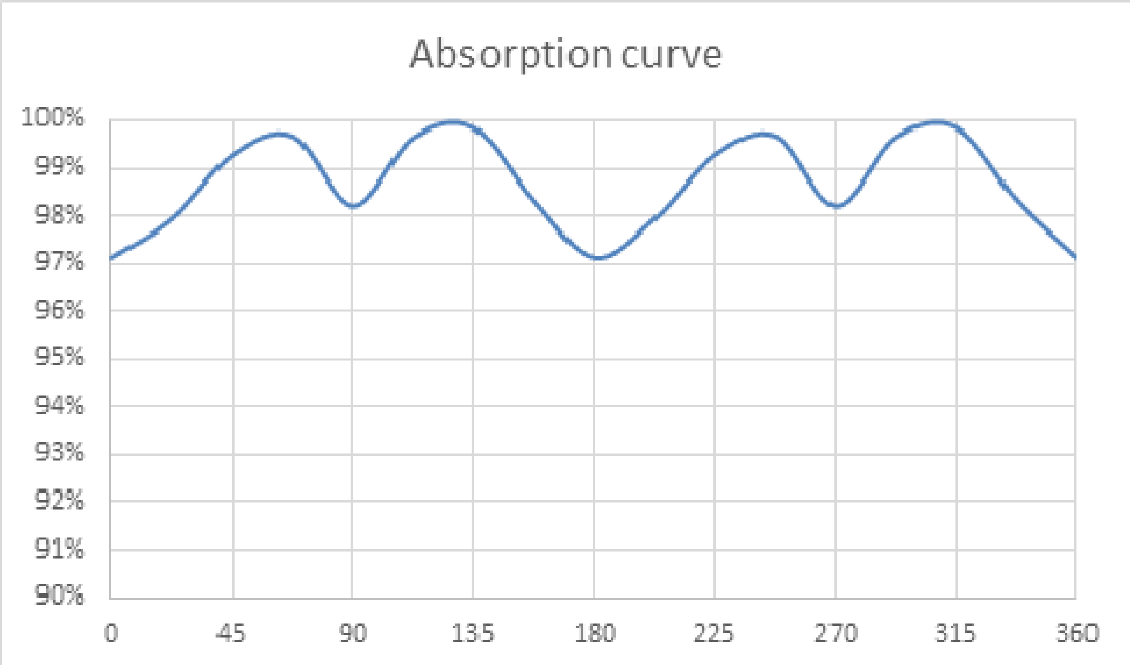

Figure 1.2.2: Coefficient of use depending on the orientation

As it can be see, the coefficient is higher than 95% in any direction. According to that, the final orientation chosen is SE-NW.

2 | Runway design

2.1 Introduction

The runway is a key piece of the airport and the air side design due to the fact that defines the maximum dimensions of the operative air planes. Its function is to successfully guarantee the landing and takeoff operation.

In order to successfully define the runway, the instructions and requirements given in the Annex 14 given by the ICAO have been followed.

2.2 Runway Length

The reference field length is defined as the minimum distance needed in order to perform a takeoff operation with the maximum homologated takeoff weight using sea level conditions, without wind and considering 0° slope.

In order to calculate the runway length, the first step is to choose the most restrictive air plane that is going to operate on that runway. Afterwards, that length has to be corrected by the runway slope, the altitude of the airport and the mean temperature.

Due to the fact that the airport has two runways, from now on, the runway used for international flights will be referred as runway 1 and the one used for domestic flights will be named runway 2.

2.2.1 Runway 1

The biggest airplanes that will operate on this runway are the Boeing 777-300ER and the Airbus A330-300.

2.2.1.1 Reference Field Length

Starting with the B777-300ER, using the ACAP (Aircraft Characteristic for Airport Planning), the values of the MTOW (Maximum TakeOff Weight) and MLW (Maximum Landing Weight) can be obtained.

2.1.1 General Characteristics: Model 777-200LR. -300ER, 777F

CHARACTERISTICS	UNITS	777-200LR	777-300ER	777-F
MAX DESIGN TAXI WEIGHT	POUNDS	768,000	777,000	768,800
	KILOGRAMS	348,358	352,442	348,722
MAX DESIGN TAKEOFF WEIGHT	POUNDS	766,000	775,000	766,800
	KILOGRAMS	347,452	351,535	347,815
MAX DESIGN LANDING WEIGHT	POUNDS	492,000	554,000	575,000
	KILOGRAMS	223,168	251,290	260,816
MAX DESIGN ZERO FUEL WEIGHT	POUNDS	461,000	524,000	547,000
	KILOGRAMS	209,106	237,683	248,115
OPERATING EMPTY WEIGHT (1)	POUNDS	320,000	370,000	318,300
	KILOGRAMS	145,150	167,829	144,379
MAX STRUCTURAL PAYLOAD	POUNDS	141,000	154,000	228,700
	KILOGRAMS	63,957	69,853	103,737
TYPICAL SEATING CAPACITY	TWO CLASS	279 (4)	339 (6)	N/A
	THREE CLASS	301 (5)	370 (7)	N/A
MAX CARGO --LOWER DECK	CUBIC FEET	5,656 (2)	7,552 (2)	22,371 (3)
	CUBIC METERS	160.2 (2)	213.8 (2)	633.5 (3)
USABLE FUEL	U.S. GALLONS	47,890	47,890	47,890
	LITERS	181,283	181,283	181,283
	POUNDS	320,863	320,863	320,863
	KILOGRAMS	145,538	145,538	145,538

Figure 2.2.1: Maximum weights of the B777 depending on its configuration.

The next step is to calculate using the following graph the takeoff distance required with standard day + 15ºC = 30ºC and sea level conditions.

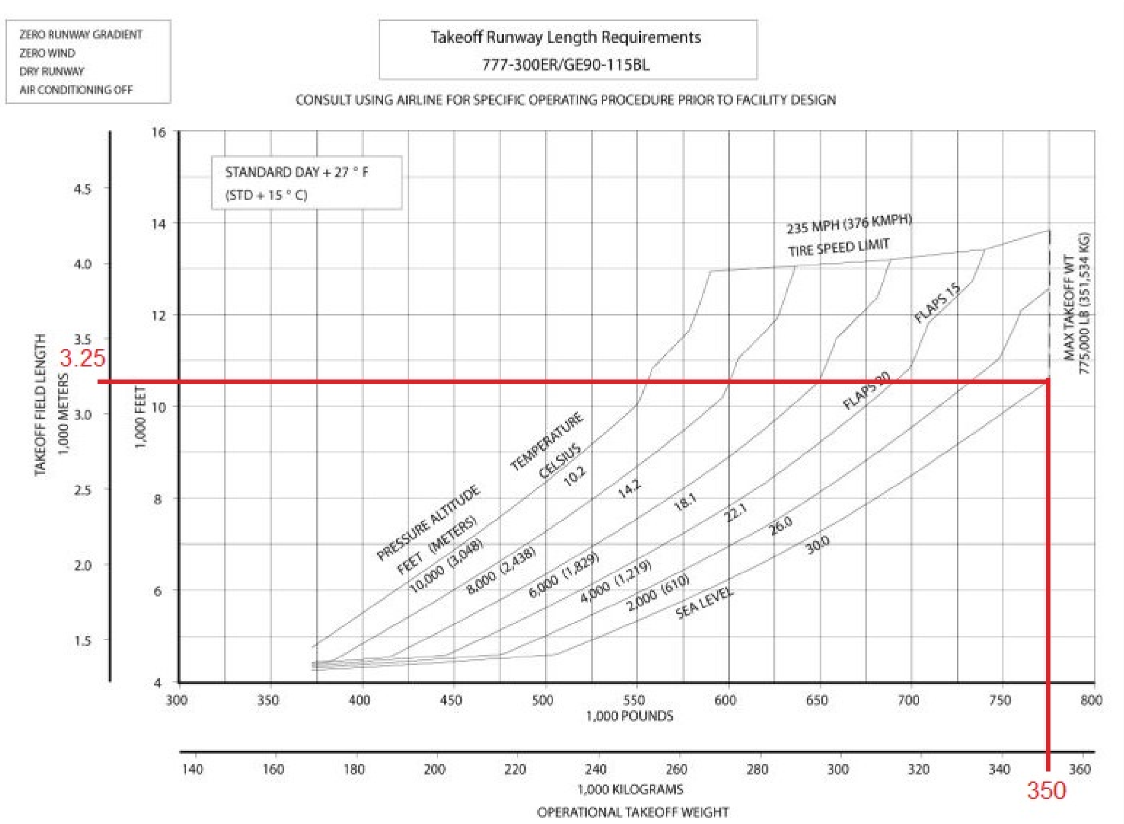

Figure 2.2.2: Relation between the MTOW and the takeoff distance.

As it is seen on the graph above, the length taken as reference (LCR) is 3.250m in a standard day+15ºC and sea level conditions.

The same procedure has to be done with the Airbus A330-300 in order to compare which one is the most restrictive one. Using the ACAP (Aircraft Characteristic for Airport Planning), the MTOW and MLW obtained are the following:

Aircraft Characteristics				
	WV000	WV001	WV002	WV003
Maximum Taxi Weight (MTW) Maximum Ramp Weight (MRW)	212 900 kg (469 364 lb)	184 900 kg (407 635 lb)	212 900 kg (469 364 lb)	215 900 kg (475 978 lb)
Maximum Take-Off Weight (MTOW)	212 000 kg (467 380 lb)	184 000 kg (405 650 lb)	212 000 kg (467 380 lb)	215 000 kg (473 994 lb)
Maximum Landing Weight (MLW)	174 000 kg (383 604 lb)	174 000 kg (383 604 lb)	177 000 kg (390 218 lb)	177 000 kg (390 218 lb)
Maximum Zero Fuel Weight (MZFW)	164 000 kg (361 558 lb)	164 000 kg (361 558 lb)	167 000 kg (368 172 lb)	167 000 kg (368 172 lb)

Figure 2.2.3: Maximum A330's weights.

Since the difference on the MTOW and MLW between both planes is greater than a 50%, the Boeing's Reference Field Length is chosen as the critical without calculating the Reference Field Length of the A330-300.

Once the most restrictive plane is chosen, the next step is to correct the length following ICAO's instructions. The equation used to correct the altitude difference is:

$$L_t = RFL * (1 + 0,07 * \frac{\Delta h}{300})$$

Solving the equation for a RFL of 3.250m and an increase on the altitude of 100m, the result obtained is 3326m. Since the temperature has already been corrected on the graph and the runway slope is going to be less than 0,5% and thus, it can be neglected, the final length will be 3.500m rounding up.

2.2.1.2 Reference code

Using the dimensions of the B777-300ER and the tables given by the ICAO, the number and letter that define the runway can be obtained.

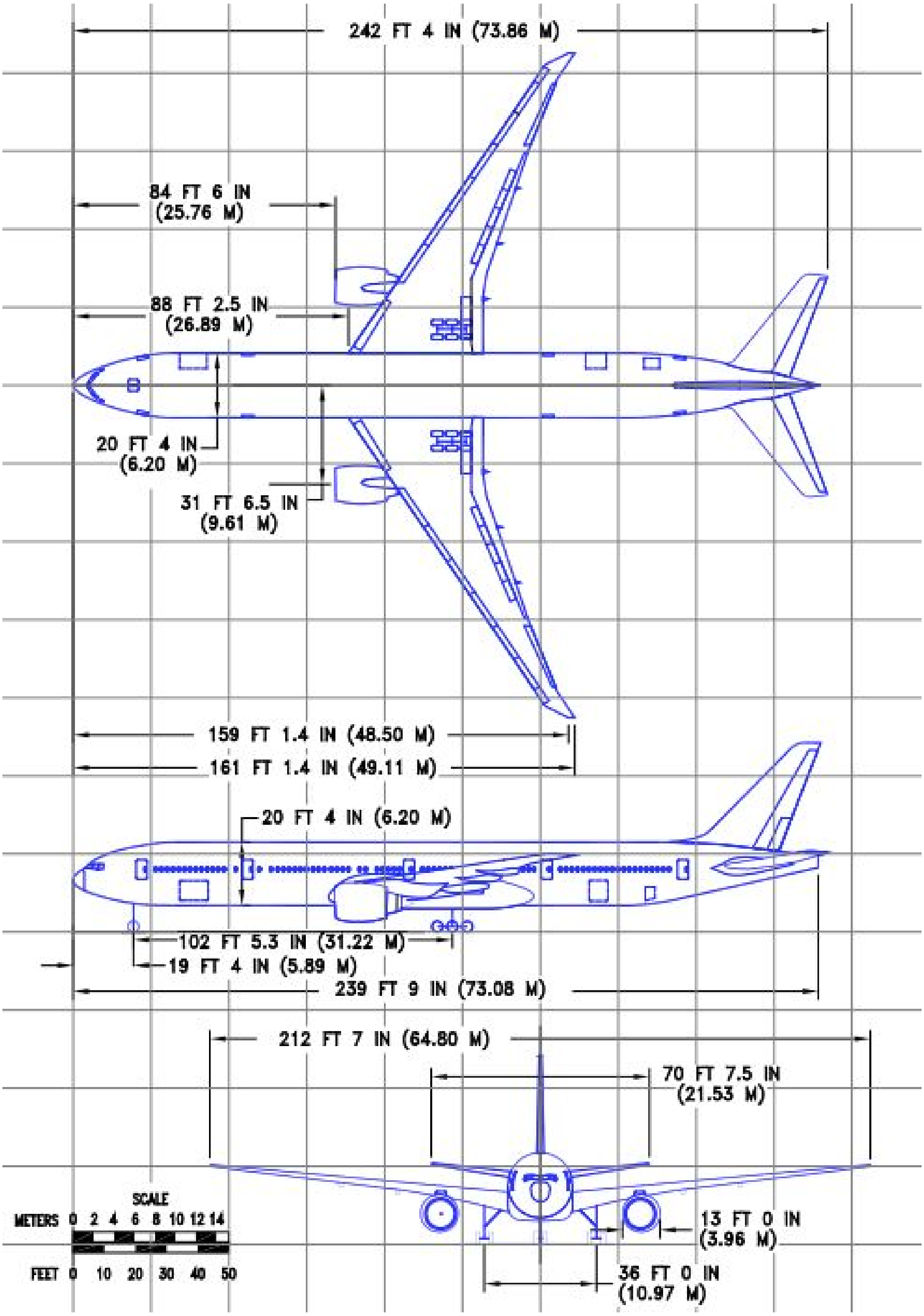

Figure 2.2.4: Boeing 777-300ER dimensions.

Code element 1		Code element 2		
Code number (1)	Aeroplane reference field length (2)	Code letter (3)	Wingspan (4)	Outer main gear wheel span[a] (5)
1	Less than 800 m	A	Up to but not including 15 m	Up to but not including 4.5 m
2	800 m up to but not including 1 200 m	B	15 m up to but not including 24 m	4.5 m up to but not including 6 m
3	1 200 m up to but not including 1 800 m	C	24 m up to but not including 36 m	6 m up to but not including 9 m
4	1 800 m and over	D	36 m up to but not including 52 m	9 m up to but not including 14 m
		E	52 m up to but not including 65 m	9 m up to but not including 14 m
		F	65 m up to but not including 80 m	14 m up to but not including 16 m

a. Distance between the outside edges of the main gear wheels.

Figure 2.2.5: Reference code given by the ICAO.

Due to the RFL being higher than 1800m , the reference number of the runway is number 4 according to ICAO and due to the dimensions of the air plane B777-300ER, which has a span of 64,8m<65m and a distance between the landing gear of 10,97m<14m, the letter that defines the airport is E.

2.2.1.3 Runway width and shoulders

The runway width is obtained using the ICAO recommendations stated on the Annex 14 and the key reference of the runway.

Code number	Code letter A	B	C	D	E	F
1[a]	18 m	18 m	23 m	–	–	–
2[a]	23 m	23 m	30 m	–	–	–
3	30 m	30 m	30 m	45 m	–	–
4	–	–	45 m	45 m	45 m	60 m

Figure 2.2.6: Runway width according to OACI.

As it can be seen, and remembering that our key reference is 4E, the minimum runway width needed is 45m. This value has to be further increased with the use of runway shoulders up to a minimum of 60m.

2.2.1.4 Declared distances

The calculations done in order to obtain the final value can be seen on the airside's attachments section 1.

To sum up, the final values obtained are:

Landing Distance Available	3.500m
TakeOff Distance Available (TODA)	4.460m
TakeOff Run Available (TORA)	3.760m
Accelerate-Stop Distance Available (ASDA)	4.360m

Table 2.2.1: Declared distances of Runway 1

An schematic figure will be attached in order to ease the understanding of the declared distances:

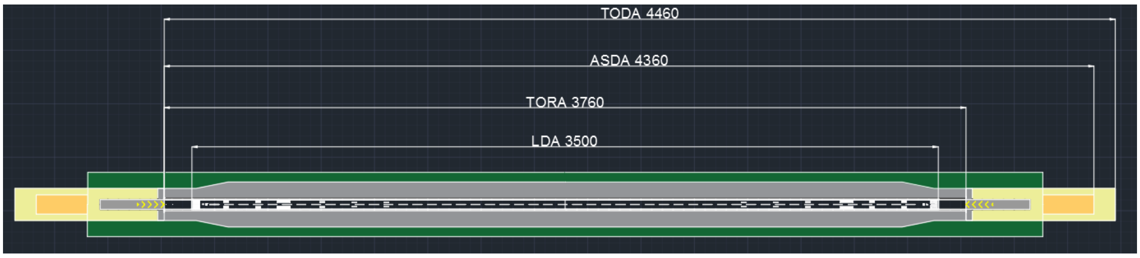

Figure 2.2.7: Declared distances on CAD.

2.2.1.5 Runway strips

The strip is a delimited area of terrain centred in the runway that has the function of reducing the air plane's risk of getting out of the runway.

According to ICAO's rule number 3.4.2 and 3.4.3, all the runways with a reference number of 4 must contain a strip in each side of the runway's axis. The minimum distance has to be 150m and has to be extended a minimum of 60m after the threshold. Following the rule 3.4.8, the first 150m from the threshold have to be separated at least 75m form the runway's axis. Past those 150m, the strip has to grow linearly until reaching the strip levelled zone.

2.2.1.6 Runway End Saefty Areas (RESA)

According to ICAO's rule number 3.5.1, the airport with a reference number of 4 has to have a runway end safety area that should extend over a distance of at least 90m. Furthermore, as it is said in the point 3.5.5, the width of a runway end safety area shall be at least twice that of the associated runway.

2.2.1.7 Clearway (CWY)

Following the recommendation number 3.6.2 and 3.6.3, the Clearway has its beginning at the end of the maximum takeoff distance available and its maximum length should be half that distance. Furthermore, the clearway should have a with of at least 75m on each side of the runway's axis.

2.2.1.8 Stopway (SWY)

When it comes to the stopway, following the ICAO's rules, the stopway shall have the same width as the runway with which it is associated.

2.2.2 Runway 2

In this case, the planes that are going to be evaluated are the Boeing 737-800 and the Airbus 320-200.

2.2.2.1 Reference Field Length

Searching the values of MTOW and MLW stated on the ACAP of the Boeing 737, the values obtained are 79.000kg for the MTOW and 66.300kg for the MLW.

CHARACTERISTICS	UNITS	MODEL 737-800, -800 WITH WINGLETS		
MAX DESIGN TAXI WEIGHT	POUNDS	156,000	173,000	174,900
	KILOGRAMS	70,760	78,471	79,333
MAX DESIGN TAKEOFF WEIGHT	POUNDS	155,500	172,500	174,200
	KILOGRAMS	70,534	78,245	$\boxed{79{,}016}$
MAX DESIGN LANDING WEIGHT	POUNDS	144,000	144,000	146,300
	KILOGRAMS	65,317	65,317	$\boxed{66{,}361}$
MAX DESIGN ZERO FUEL WEIGHT	POUNDS	136,000	136,000	138,300
	KILOGRAMS	61,689	61,689	62,732
OPERATING EMPTY WEIGHT (1)	POUNDS	91,300	91,300	91,300
	KILOGRAMS	41,413	41,413	41,413
MAX STRUCTURAL PAYLOAD	POUNDS	44,700	44,700	47,000
	KILOGRAMS	20,276	20,276	21,319
SEATING CAPACITY (1)	TWO-CLASS	160	160	160
	ALL-ECONOMY	184	184	184

Figure 2.2.8: Maximum weights of the B737 depending on its configuration.

As for the B777, the next step is to calculate using the following graph the takeoff distance required with standard day + 15ºC = 30ºC and sea level conditions using the MTOW.

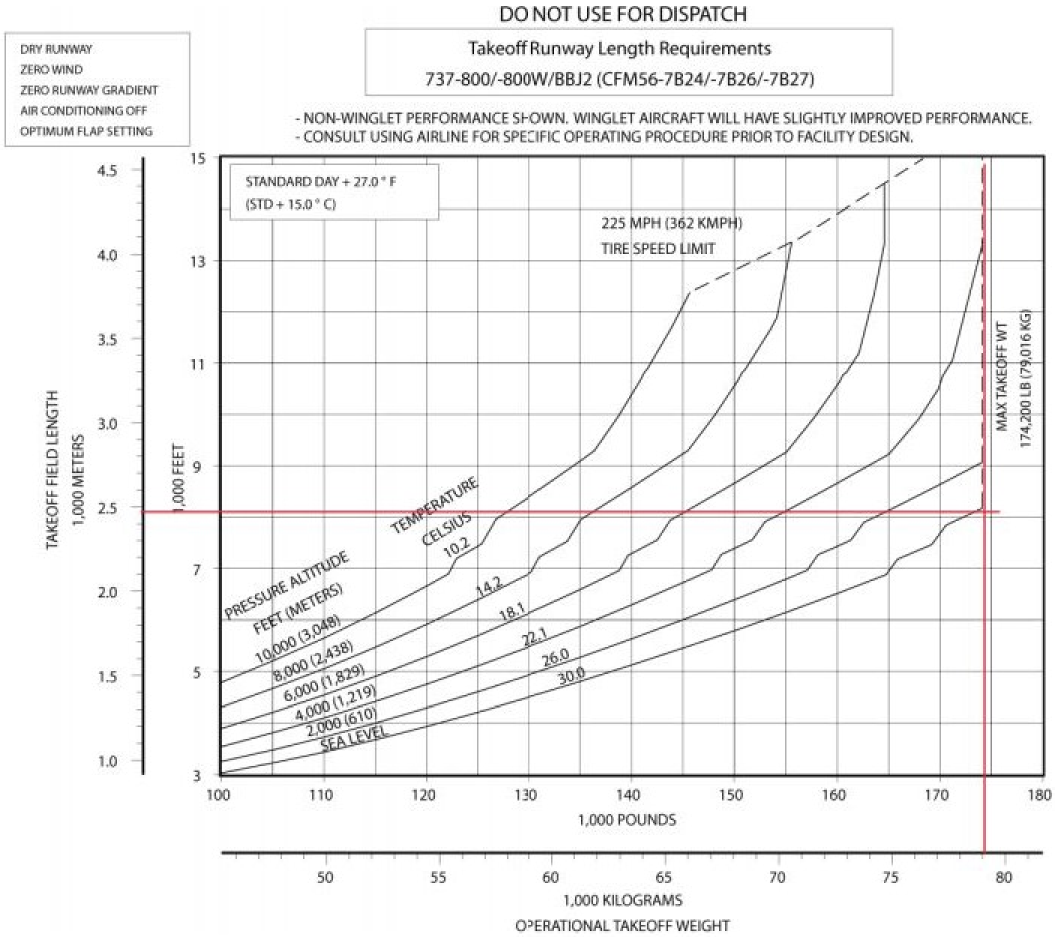

Figure 2.2.9: Relation between the MTOW and the takeoff distance.

The value of the RFL obtained is 2.450m approximately in standard day and sea level conditions.

The same procedure has to be done with the Airbus A320-200 in order to compare which one is the most restrictive one. Using the ACAP (Aircraft Characteristic for Airport Planning), the MTOW and MLW obtained are the following:

Aircraft Characteristics					
	WV000	WV001	WV002	WV003	WV004
Maximum Ramp Weight (MRW) Maximum Taxi Weight (MTW)	73 900 kg (162 922 lb)	68 400 kg (150 796 lb)	70 400 kg (155 205 lb)	75 900 kg (167 331 lb)	71 900 kg (158 512 lb)
Maximum Take-Off Weight (MTOW)	73 500 kg (162 040 lb)	68 000 kg (149 914 lb)	70 000 kg (154 324 lb)	75 500 kg (166 449 lb)	71 500 kg (157 630 lb)
Maximum Landing Weight (MLW)	64 500 kg (142 198 lb)	64 500 kg (142 198 lb)	64 500 kg (142 198 lb)	64 500 kg (142 198 lb)	64 500 kg (142 198 lb)
Maximum Zero Fuel Weight (MZFW)	60 500 kg (133 380 lb)	60 500 kg (133 380 lb)	60 500 kg (133 380 lb)	60 500 kg (133 380 lb)	60 500 kg (133 380 lb)

Figure 2.2.10: Maximum weights of the A320 depending on its configuration.

Due to the fact that the MTOW and the MLW of the B737 are higher than the A320 ones, the plane B737 is chosen as the critical for the design of the runway.

The next step is to correct the field length using the equation stated above, on the calculations for runway 1.

$$L_t = RFL * (1 + 0,07 * \frac{\Delta h}{300})$$

Solving the equation for a RFL of 2.450m and an increase on the altitude of 100m, the result obtained is 2500m. The same hypotheses used on the runway number 1 will be applied regarding the temperature and slope of the runway. Thus, the final length will be 2500m.

2.2.2.2 Reference code

Using the dimensions of the B737-800 and the tables given by the ICAO, the number and letter that define the runway can be obtained.

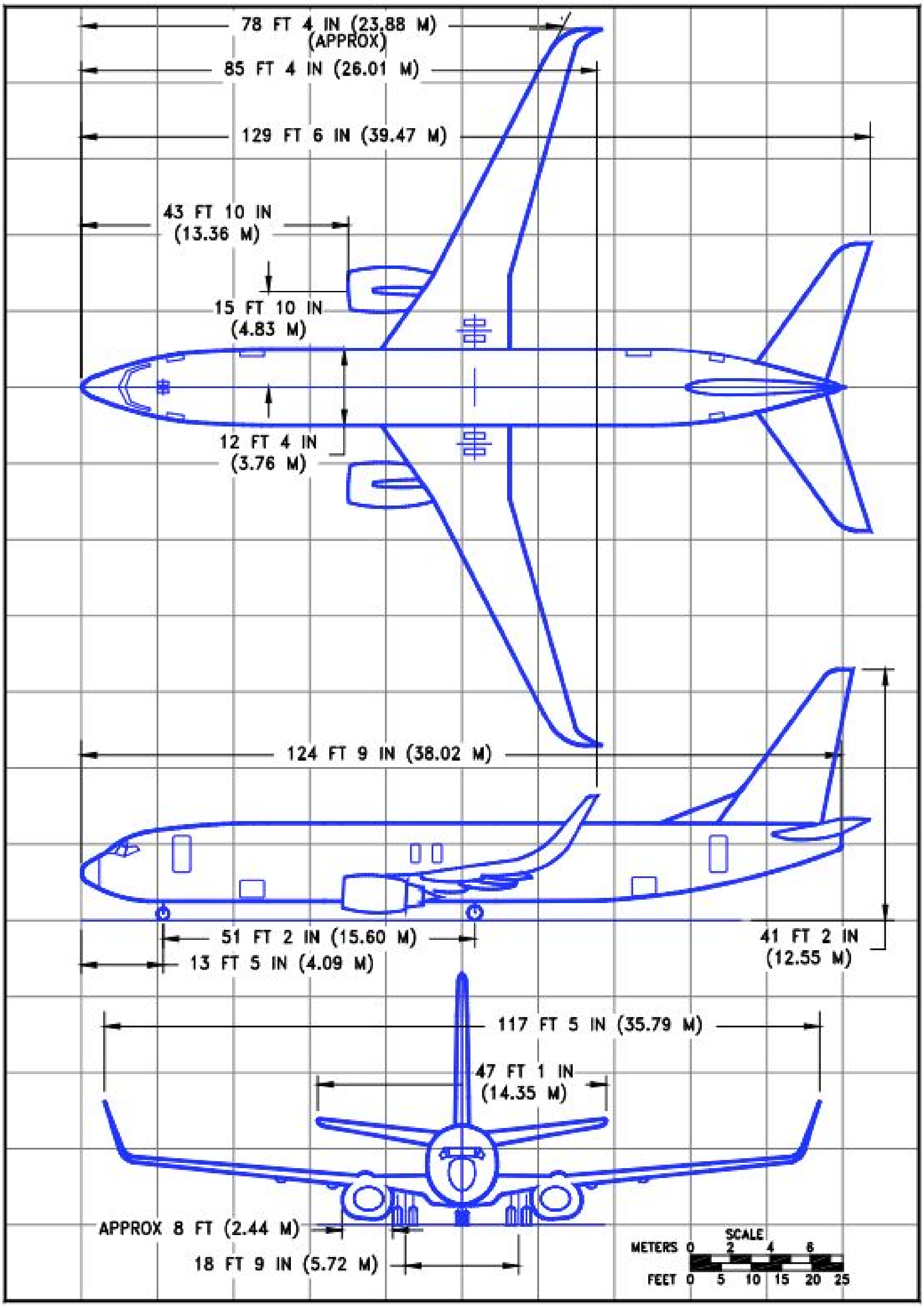

Figure 2.2.11: Boeing 737-800 dimensions.

Due to the RFL being higher than 1800m , the reference number of the runway is 4 according to ICAO and due to the dimensions of the air plane B737-800, which has a span of 35,8m<36m and a distance between the landing gear of 6m<9m, the letter that defines the airport is C.

2.2.2.3 Runway width and shoulders

The runway width is obtained using the ICAO recommendations stated on the Annex 14 and the key reference of the runway.

Code number	Code letter					
	A	B	C	D	E	F
1ª	18 m	18 m	23 m	–	–	–
2ª	23 m	23 m	30 m	–	–	–
3	30 m	30 m	30 m	45 m	–	–
4	–	–	45 m	45 m	45 m	60 m

Figure 2.2.12: Runway width according to OACI.

As it can be seen, and remembering that our key reference is 4C, the minimum runway width needed is 45m. This value has to be further increased with the use of runway shoulders up to a minimum of 60m.

2.2.2.4 Declared distances

As for the runway 1, the calculations done in order to obtain the final value can be seen on the airside's attachments section 1.

To sum up, the final values obtained are:

Landing Distance Available	3.500m
TakeOff Distance Available (TODA)	3.760m
TakeOff Run Available (TORA)	4.460m
Accelerate-Stop Distance Available (ASDA)	4.360m

Table 2.2.2: Declared distances of Runway 2

2.2.2.5 Runway strips

2.2.2.6 Stopway (SWY)

2.2.2.7 Clearway (CWY)

3 Taxiway design

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5 Apron design

5.1 Introduction

The apron is the area of an airport where the aircraft are parked, unloaded or loaded, refuelled and boarded. It also has to cover the taxiways and the trajectories that air planes have to take in order to get to the principal taxiways or the station zones.

Another function that the apron has to full-fill is the creation of a service way that will allow all the different services needed by the plane to get to it and the creation of some waiting positions for them that will not obstacle the manoeuvres of the plane. Last but not least, the connection between air-side and land-side is under the responsibility of the apron.

Before moving into a more detailed explanation of each part that makes the apron, a general view is going to be attached in order to obtain a general idea of what is the apron.

Code number	Code letter					
	A	B	C	D	E	F
1^a	18 m	18 m	23 m	–	–	–
2^a	23 m	23 m	30 m	–	–	–
3	30 m	30 m	30 m	45 m	–	–
4	–	–	45 m	45 m	45 m	60 m

Figure 5.1.1: Runway width according to OACI.

The sections of the apron that will be further explained are the apron taxiways, the aircraft stands, the apron trajectories, service ways and terminal connections.

5.2 Apron taxiways

5.3 Aircraft stands

5.3.1 General dimensions of aircraft stands

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6.2.1 Taxiway centerline markings

6.2.2 Taxiway strip markings

6.2.3 Taxiway holding position markings

6.2.4 Intermediate holding position markings

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6.2.6 Mandatory instruction marking

6.3 Apron markings

6.3.1 Apron lead in line markings

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7.1.2 Approach slope indication systems

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7.1.4 Runway edge lights

7.1.5 Runway threshold and wing bar lights

7.1.6 Runway end lights

7.1.7 Touchdown zone lights

7.1.8 Runway rapid exit lights

7.2 Taxiway lights

7.2.1 Taxiway lights

7.2.2 Taxiway lights for an exit taxiway

7.2.3 Taxiway light for a rapid exit taxiway

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